Reproductive System and Gonadal Activities in *Lamellidens marginalis* (Simpson, 1900)

BY

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(10 Text figures)

THE EDIBLE FRESH WATER MUSSEL, *Lamellidens marginalis*, is most common in ponds and large bodies of perennial water in the Indian subcontinent, and especially so in West Bengal. Usually the mussels are fairly large in size, measuring about 85 × 47 mm and weighing nearly 50 g, more than 50% of which is the weight of the shell. In West Bengal the mussels are active throughout the year, though they exhibit somewhat higher activity during the rainy seasons and early post monsoon period.

Though quite detailed information on the reproductive system of *Lasaea rubra* (Montagu, 1804) and *Turtonia minuta* (Fabricius, 1780), belonging to the family Erycinidae (OLDFIELD, 1955), *Nucula delphinodonta* (DREW, 1901), *Ostrea cucullata* (AWATI & RAI, 1931), and other Unionidae (LILLIE, 1895, 1901) is available, we are not aware of any literature dealing with the same subject of the genus *Lamellidens*. The reproductive system of *Lamellidens*, however, greatly resembles that of *Lasae rubra*, *Turtonia minuta*, *Actinonaias ellipsiformis* (VAN DER SCHALIE & VAN DER SCHALIE, 1963), *Ostrea* (HOLLIS, 1963), and *Carunculina patrickae* (BATES, 1966) in the relative position of the gonad, in spawning, in ovoviviparity and also in the embryos developing in the brood pouches of the female.

MATERIALS AND METHODS

Robust and healthy specimens were collected from large, perennial ponds. For routine dissection, mussels were killed in well stretched state by placing them in a large jar full of water and sprinkling a few crystals of thymol and menthol on the surface and leaving the jar undisturbed overnight.

Tissues for microscopic preparations were collected from living specimens. Fixatives such as Bouin's fluid, Carnoy, Zenker and Smith's fixative, gave excellent results. Sections were cut 4 - 6μ thick, either stained with Delafield Haematoxylin and counterstained with Eosin, or simply with Heidenhain's iron Haematoxylin. Figures were drawn with the help of a camera lucida.

OBSERVATIONS

The region bounded anteriorly by the mouth and the labial palps, dorsally by the gills and the suprabranchial chamber, posteriorly by the posterior portion of the gills, and ventrally by the foot is commonly known as the visceral mass. The major part of the visceral mass is constituted by the gonad, the rest being occupied by the stomach, coil of the intestine and digestive gland. The dull brownish digestive gland occupies about one fourth of the total volume of the visceral mass and bounds the gonad anteriorly and antero-ventrally, extending posteriorly about half the length of the gonad. Anteriorly and antero-ventrally, the gonad projects over the digestive gland and partially covers it (Figure 1).

The visceral mass is covered externally by a tough membranous structure made of muscle fibers arranged in 3 distinct layers. The outermost layer is of intermediate thickness and is formed by closely packed narrow muscle bands of longitudinal fibers. The middle layer is slightly thinner than the outer one and consists of transversely oriented muscle fibers. The innermost layer is about 8 times as thick as the middle layer and formed of close-set blocks of muscles made up of longitudinally arranged fibers.

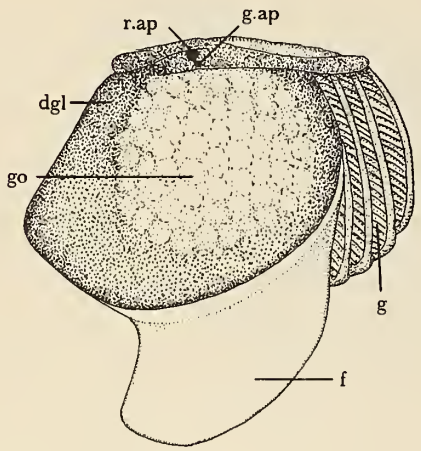

Figure 1

Reproductive system of *Lamellidens marginalis* showing gonopore (lateral view)

dgl – digestive gland f – foot g – gill
g.ap – gonopore go – gonad r.ap – renal aperture

The Gonads:

The sexes are separate. In a mature specimen the gonad is whitish in colour in males during the breeding season, while in females it is cream coloured. Both testis and ovary are made up of a large number of oval follicles held together by connective tissue except those in the lateral borders where the connective tissue is absent. In both sexes the two gonads coalesce in an adult mussel and the gonad of one side could not be separated from that of the other side, though separate gonoducts with their openings are retained.

Figure 2

Transverse section of male gonad

The Testis:

A testicular follicle (Figure 2) in the breeding season measures about 240 × 150μ on the average, though a wide variation in size is often encountered. It is bounded by a layer of extremely flattened cells with inconspicuous nucleus and non-granulated cytoplasm. The separating cell membranes are not traceable. The major portion of the follicle is occupied by groups of rounded cells of varying size and different stages of spermatogenesis can be found in a follicle at the same time throughout the year. The spermatogonia are spherical, and large granules taking up deep basic stains are restricted towards one side.

Figure 3

Transverse section of gonoduct

Smaller granules, showing strong affinity for acid dyes, are scattered through the rest of the cytoplasm. The nucleus is ordinarily not traceable. The gonadal activity is higher in the breeding season and the lumina of most of the follicles are almost obliterated by spermatocytes and spermatozoa.

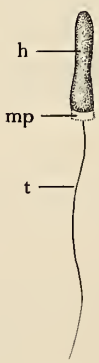

Figure 4

A spermatozoon

h – head piece mp – middle piece t – tail

The head of a spermatozoon is slightly narrower anteriorly, truncate posteriorly, and measures $3 \times 1.2\mu$. The middle piece (0.61μ) is a narrow, band-like structure, takes up deep basic stain and a constriction between it and the head is lacking. The tail is of medium length (7.4μ), almost transparent, as it does not take up any stain and can be seen only with considerable difficulty (Figure 4). The spermatozoa were never found to be arranged in bundles.

The Ovary:

The ovarian follicles exihibit great diversity in shape and size, and on the average measure $350 \times 220\mu$ in the breeding season. Structurally an ovarian follicle is similar to a testicular follicle. The histology of the ovary presents apparently somewhat different pictures in different seasons of the year, depending on the gonadal activity. In the quiescent phase (February to March), however, the follicular wall appears quite thick due to the presence of a few spherical oogonia and numerous nurse cells (Figure 5).

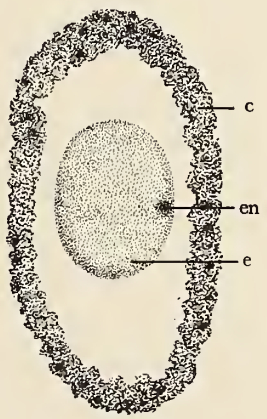

Figure 5

Section of female gonad in quiescent phase (February to March)
c – capsule e – egg en – egg nucleus

With the commencement of the preparatory phase a large number of spherical yolk granules are seen to accumulate in the follicle along its periphery and surround the oogonia. During this period, April to July, the oogonia undergo divisions, yolk granules pass to developing ova, and due to a certain depletion of the amount of yolk granules and nurse cells the wall of the follicle becomes thinner. Vitelline membranes appear around the eggs (Figure 6).

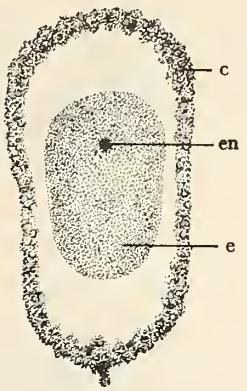

Figure 6

Section of female gonad in preparatory phase (April to July)
c – capsule e – egg en – egg nucleus

In the active phase, July to January, a follicle contains ripe ova and a complete depletion of nurse cells renders the wall very thin. During the breeding season almost all the follicles contain ova in different stages of maturation, the number of which varies from 1 to 4 (Figure 7). More than 4 ova in a follicle, though not impossible, is, however, of rare occurrence.

Figure 7

Section of female gonad in active phase (July to January)

A mature ovum (Figure 8) is a large, spherical body about 150μ in diameter, containing a 40μ round nucleus with a small nucleolus. The space between the ovum and its vitelline membrane is filled up with an albuminous fluid.

The polar bodies are separated from a point opposite of the micropyle and measure about 53μ in diameter. The first polar body (Figure 9) appears while the ovum is still within the follicle. The second polar body is formed after ovulation and in all probability immediately before

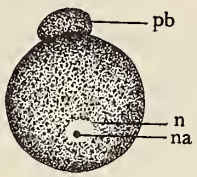

Figure 8

A mature egg

n – nucleus na – nucleolus pb – polar body

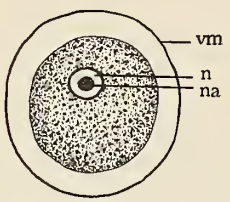

Figure 9

An egg with first polar body

n – nucleus na – nucleolus

vm – vitelline membrane

the entrance of the spermatozoon into the ovum; a number of zygotes with polar body attached to it was collected from brood pouches.

The Gonoduct:

In both testis and ovary, the lumina of a number of follicles unite to a narrow duct made up of a single layer of flattened cells. A few of these ducts join to form a somewhat larger duct, which consists of a single layer of elongated columnar, ciliated cells supported by a homogenous basement membrane. The nucleus is elongated and situated towards the free end of the cell (Figure 3). The gonoduct finally formed is supported by muscle fibers and measures about 2 mm in length. The oval gonopore is nearly 1 mm long, devoid of a rim, and located ventral to the renal aperture.

Gonadal Activity:

The male gonad is active throughout the year though the activity increases considerably during the breeding season. The activity of the female gonad measured by the presence of mature ova in the ovarian follicle continues for 10 months in a year, but at different tempi (Figure 1).

DISCUSSION

Taken as a whole, the bivalves may be regarded as a group characterised by gonochorism. About 96% of the species included in the class are dioecious (Coe, 1943), though hermaphroditic species – *viz. Ostrea lutaria* (Hollis, 1963) and occasional hermaphroditism in *Actinonaias ellipsiformis* (van der Schalie & van der Schalie, 1963) – are on record. Members of the family Sphaeriidae are, however, both hermaphroditic and larviparous - with separate ovaries and testes, but common gonoduct: *Sphaerium striatinum* (Wood, 1931); *Musculium heterodon* (Okada, 1935); *Pisidium conventus* (Odhner, 1951); *Sphaerium musculium partumeium* (Thomas, 1959). Sexual dimorphism is absent possibly except in *Carunculina patrickae* (Bates, 1966), where the female is identified by shells rounded both anteriorly and posteriorly, and the males with shells pointed posteriorly. From the colour of the gonad, which is usually cream in females and whitish in males, the sexes, however, are distinguishable (Drew, 1901; van der Schalie & van der Schalie, 1963).

The anatomical simplicity of the reproductive organs of *Lamellidens marginalis* and other bivalves in general reflects their simple sexual reactions (Hollis, 1963). The mature gonad is large, relative to the size of the individuals, and the female produces many yolky eggs. These facts are correlated with the breeding habits and external fertilization in *Ostrea cucullata* (Awati & Rai, 1931); *Lasaea rubra* (Oldfield, 1955); *Actinonaias ellipsiformis* (van der Schalie & van der Schalie, 1963); *Carunculina patrickae* (Bates, 1966) and *Lamellidens marginalis*.

Studies on gonadal activity of bivalves are very limited. *Lamellidens,* like other bivalves, are typically bradytictic (long term breeding cycle) in which gills remain gravid with devcloping embryos for a considerable period of the year, a situation similar to that met with in the majority of the bivalves. Spermatogenesis occurs in all months of the year, at an unequal tempo, of course, the period of highest activity being July to January when the follicles of the testis remain heavily loaded with sperms. In *Pisidium* (Heard, 1965) however, spermatogenesis takes place only for a brief period in early summer.

In the majority of the bivalves the female gonad, in contrast to the male gonad, exhibits periodic activity, though oogenesis, while the larvae of the previous year are still in thc brood pouch, is of common occurrence. *Pisidium* (Heard, 1964) appears to be unique, as unlike in other known cases, oogenesis occurs in all seasons, being most active in early summer, while spermatogenesis occurs

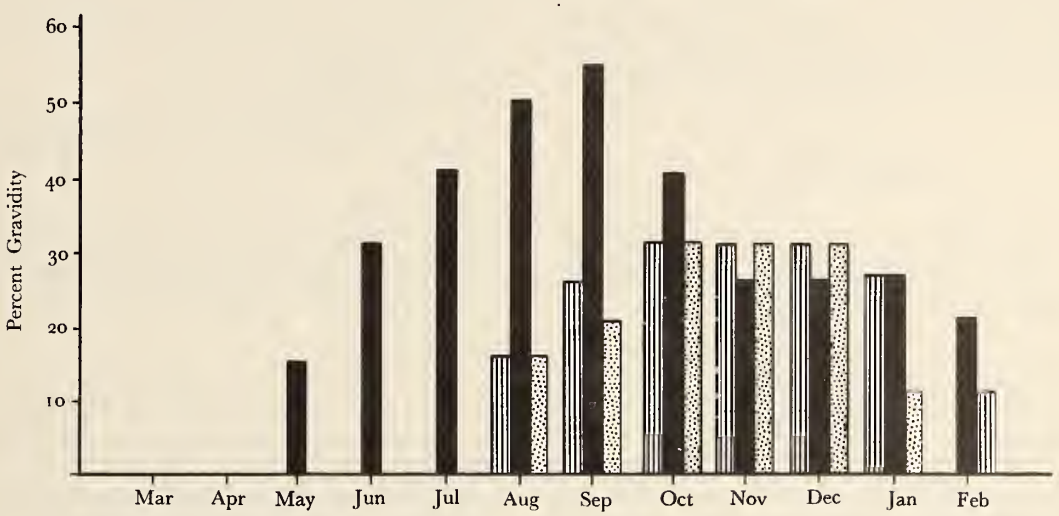

Figure 10

Gonadal activity in *Lamellidens marginalis*

only for a brief period, synchronizing with the maximum production of ova. In sphaerid clams, spermatogenesis and oogenesis take place at the same time (THOMAS, 1959).

Oogenesis occurs for about 8 months in *Ostrea* (HOLLIS, 1963), throughout the year in *Actinonaias ellipsiformis* (VAN DER SCHALIE & VAN DER SCHALIE, 1963) and throughout most of the year in *Carunculina patrickae* (BATES, 1966). A marked periodic activity is found in the ovary of *Lamellidens marginalis* which is active for about 10 months in the year. The whole period may be divided into 3 distinct phases. The quiescent phase or inactive period starts from early or middle of February and extends up to the end of March. The preparatory phase covers April to May, and a new crop of oocytes is produced during this period. In a good percentage, both phases continue for a much longer period. The active period is longest, ranging from June to next January, during which gametogenesis, growth, and maturation of ova take place. The long active period is a characteristic of the species, but in no case does the period extend beyond a couple of months in an individual.

The size and shape of the sperm in *Lamellidens* differs greatly from *Ostrea cucullata* (AWATI & RAI, *op. cit.*) and *Lasaea rubra* (OLDFIELD, *op. cit.*). The sperm is short in length and consists of a deeply staining head and a slender, unstainable protoplasmic tail about 3 times longer than the head, while in *O. cucullata* the tail is 10 times longer.

The short gonoduct opens into separate pores, ventral to the renal aperture. This is somewhat similar to the condition in *Ostrea cucullata* (AWATI & RAI, *op. cit.*), where the gonadal apertures are situated in the renogonadal grooves, dorsal to the renal aperture on either side of the pylorus. The 2 apertures indicate the paired origin of the gonads during development.

SUMMARY

1. The reproductive system of *Lamellidens marginalis* consists of a voluminous gonad formed by the fusion of two gonads, and a pair of short ducts opening to the exterior by elongate-ovate apertures.
2. The spermatozoa are about 12μ long, bearing a small (3.6μ) head, while the ova measure 150μ in diameter.
3. The first polar body appears while the ovum is still within the ovarian follicle; the second polar body is formed after ovulation.

4. No seasonal activity is found in the male germ cells; spermatozoa are produced throughout the year, though at a different rate.
5. Periodicity is present in the female gonad; this can be divided into three phases: a quiescent phase, a preparatory phase, and an active phase.

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